

*What is claimed is:*

## **CLAIMS**

1. A haptic feedback trackball device coupled to a host computer implementing a host application program, said haptic feedback device used by a user to provide input to said host computer, the haptic feedback device comprising:

a housing that is physically contacted by said user, said housing resting on a support surface;

a sphere positioned in said housing, said sphere rotatable in two rotary degrees of freedom;

a sensor device coupled to said housing of said mouse, said sensor device detecting said movement of said sphere in said rotary degrees of freedom and outputting sensor signals representative of said movement; and

an actuator coupled to said housing of said device, said actuator operative to apply a force to said housing approximately along an axis that is substantially perpendicular to said support surface, wherein said force is transmitted to said user contacting said housing.

2. A trackball device as recited in claim 1 wherein said force is an inertial force that is output approximately along said axis that is substantially perpendicular to said support surface, wherein said actuator outputs said inertial force to said housing by moving an inertial mass.

3. A trackball device as recited in claim 2 wherein said inertial force is correlated with a graphical representation displayed by said host computer, wherein a position of said sphere in said rotary degrees of freedom corresponds with a position of a cursor displayed in said graphical representation.

4. A trackball device as recited in claim 2 wherein said inertial force is a pulse correlated with the interaction of a user-controlled cursor with a graphical object displayed in a graphical user interface.

5. A trackball device as recited in claim 4 wherein said pulse is output when said cursor moves between menu items in a displayed graphical menu.

6. A trackball device as recited in claim 1 wherein said force is included in a force sensation, said force sensation being one of a pulse, vibration, and texture force.

7. A trackball device as recited in claim 1 wherein said force is a contact force that is provided by driving a moving element that contacts said user using said actuator.

5        8. A trackball device as recited in claim 7 wherein said moving element is a cover portion of said housing, said cover portion being movably coupled to a base portion of said housing.

9. A trackball device as recited in claim 7 wherein said moving element is a button, said button also for providing button input to said host computer.

10       10. A trackball device as recited in claim 1 wherein at least one compliant element is coupled to said housing, said compliant element supporting said housing on said support surface and including a compliance, said compliance allowing said force to be greater in magnitude than if said housing contacted said support surface directly.

15       11. A trackball device as recited in claim 10 wherein said at least one compliant element comprises rubber or foam.

20       12. A trackball device as recited in claim 1 further comprising a microprocessor, separate from said host computer, coupled to said sensor device and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said force, and operative to receive said sensor signals from said sensor device, process said sensor signals, and report locative data to said host computer derived from said sensor signals and indicative of said movement of said sphere.

13. A trackball device as recited in claim 1 wherein said actuator outputs said force in response to a command received by said trackball device from said host computer.

25       14. A haptic feedback trackball device coupled to a host computer implementing a host application program, said haptic feedback device used by a user to provide input to said host computer, the haptic feedback device comprising:

a housing that is physically contacted by said user, said housing resting on a support surface;

a sphere positioned in said housing, said sphere rotatable in two rotary degrees of freedom;

5 a sensor device coupled to said housing of said mouse, said sensor device detecting said movement of said sphere in said rotary degrees of freedom and outputting sensor signals representative of said movement;

an actuator coupled to said housing of said device, said actuator operative to apply a force to said housing, wherein said force is transmitted to said user contacting said housing; and

10 at least one compliant element coupled between a portion of said housing contacted by said user and said support surface, said at least one compliant element amplifying said force output from said actuator by allowing said contacted portion of said housing to move with respect to said support surface.

15 15. A trackball device as recited in claim 14 wherein said at least one compliant element includes at least one compliant foot provided between said housing and said support surface.

16. A trackball device as recited in claim 14 wherein said at least one compliant element includes a compliant coupling provided between said contacted portion of said housing and a different portion of said housing.

17. A trackball device as recited in claim 14 wherein said force is output approximately along an axis that is substantially perpendicular to said support surface.

20 18. A trackball device as recited in claim 14 wherein said force is correlated with the interaction of a user-controlled cursor with a graphical object displayed in said graphical environment.

19. A trackball device as recited in claim 14 wherein said force is an inertial force, and wherein said actuator outputs said inertial force to said housing by moving an inertial mass.

25 20. A trackball device as recited in claim 19 wherein said actuator is provided in an actuator assembly that includes a flexure, said flexure providing a centering spring force to said inertial mass.

21. A trackball device as recited in claim 14 wherein said force is a contact force, and wherein said actuator drives a moving element that contacts said user.

22. A trackball device as recited in claim 14 further comprising a microprocessor, separate from said host computer, coupled to said sensor and to said actuator, said microprocessor operative to receive host commands from said host computer and output force signals to said actuator for controlling said force, and operative to receive said sensor signals from said sensors, process said sensor signals, and report locative data to said host computer derived from said sensor signals and indicative of said movement of said sphere.

23. A trackball device as recited in claim 14 wherein said actuator is a first actuator, and further comprising a second actuator for outputting a force on said sphere in one of said two degrees of freedom of said sphere.

24. A trackball device as recited in claim 23 wherein said second actuator is a passive brake for providing a resistance to motion of said sphere.

25. A method for providing haptic feedback to a user interacting with a graphical environment displayed by a host computer, the user manipulating a trackball device, the method comprising:

detecting the motion of a sphere of said trackball device in two rotary degrees of freedom and providing an indication of said motion to said host computer;

receiving information from said host computer indicating that a tactile sensation is to be output, said tactile sensation being correlated with an interaction or event occurring within said graphical environment; and

outputting a force on the housing of said trackball device using an actuator, said force being approximately along an axis substantially perpendicular to a surface supporting said trackball device, wherein said user can contact said housing and experience said force.

26. A method as recited in claim 25 wherein said force is an inertial force caused by moving an inertial mass coupled to said actuator.

27. A method as recited in claim 25 wherein said force is a contact force caused by driving a moving element with said actuator to contact said user.